Evaluation of regional reanalyses with microwave satellite observations using a feature identification algorithm

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So far atmospheric reanalyses have been available mainly as global products with relatively coarse resolutions. In recent years, there has been a tendency towards creating regional reanalyses on smaller domains but with higher resolutions. Since reanalyses are often regarded as "the truth" by their users, one important question is whether higher resolved reanalyses are able to better capture small-scale features such as individual convective cells.

This study investigates the representation of convective cells and frontal systems in differently resolved reanalysis products developed within the Hans Ertel Centre for Weather Research and compares them to a downscaling product and microwave satellite observations. A realistic representation of small-scale precipitation is important for many applications, e.g. regional climate assessment or hydrological modeling.

Microwave brightness temperatures observed from satellites at frequencies above 90 GHz are a valuable indicator for surface precipitation. Regions of low brightness temperatures indicate scattering at large ice or snow particles in deep clouds, which is often connected with precipitation at the surface. A comparison to rain gauge measurements clearly illustrates this connection. Due to their high areal coverage, satellite measurements are especially well suited to complement rain gauge data in regions with a lack of surface stations. Satellite data have not been assimilated into the considered reanalysis products, which makes them a valuable source for evaluation.

The microwave forward operator PAMTRA (Passive and Active Microwave TRAnsfer) is used to simulate brightness temperature fields from the 3-dimensional reanalysis output. Ice particles are assumed with rather simplified shape in models underlying the reanalysis. A sensitivity study with PAMTRA investigated the impact of the use of different snow particle habits, such as soft spheres, dendrites, or sector snowflakes and has shown that the uncertainty associated with the particle habit can reach values of more than ten Kelvin. This high uncertainty makes it worthwile to use a gradient-based feature identification algorithm that is practically insensitive to a certain brightness temperature threshold. Instead of investigating the actual brightness temperature values, the evaluation of the products is based on the identified objects.

Several reanalysis products and a downscaling product all based on the COSMO model are analyzed. The reanalysis products include a 6 km resolution reanalysis, a 6 km reanalysis including Latent Heat Nudging, which is used to additionally assimilate radar data, and a 2 km reanalysis. These products are compared to satellite observations at 150 and 157 GHz obtained from NOAA and MetOp satellites, respectively.

Case studies show that some convective cells, that are well captured in the 2 km product, are missing in the 6 km product. It is likely that the Latent Heat Nudging plays a role in this better representation and that the 6 km product including Latent Heat Nudging will be superior to the one without Latent Heat Nudging. For frontal systems, the difference between the reanalysis products is less pronounced. The objects identified using the feature identification algorithm in the reanalyses and observation will be evaluated using various statistical measures.